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REPORT

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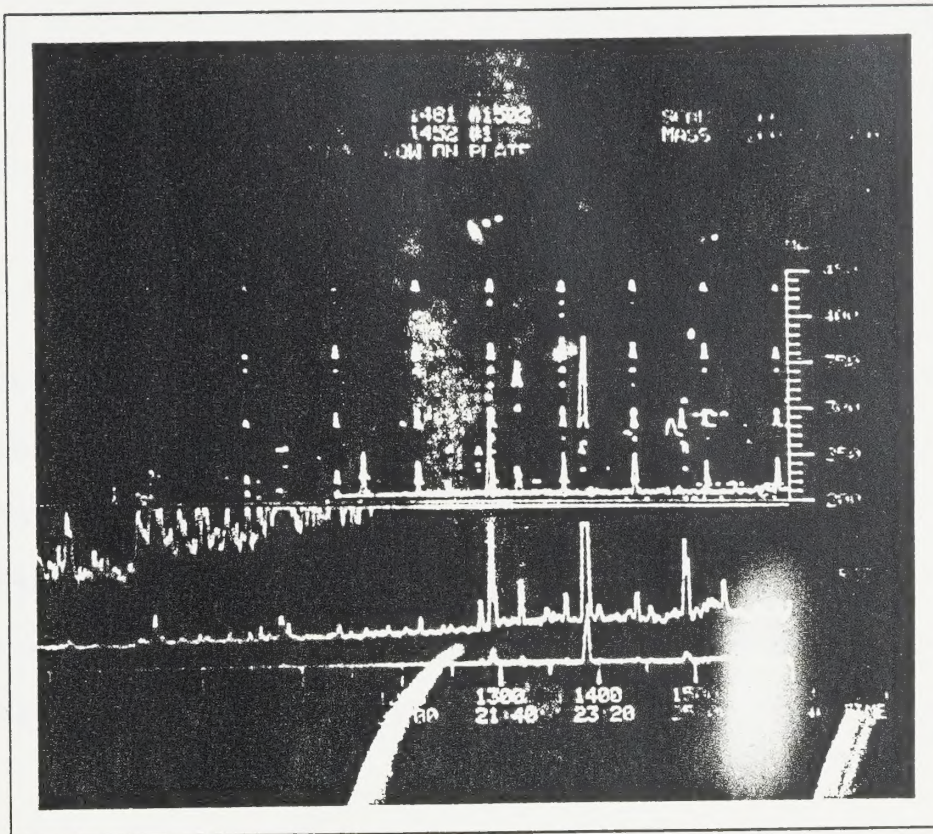
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ANALYSIS OF PRE AND POST FLARE

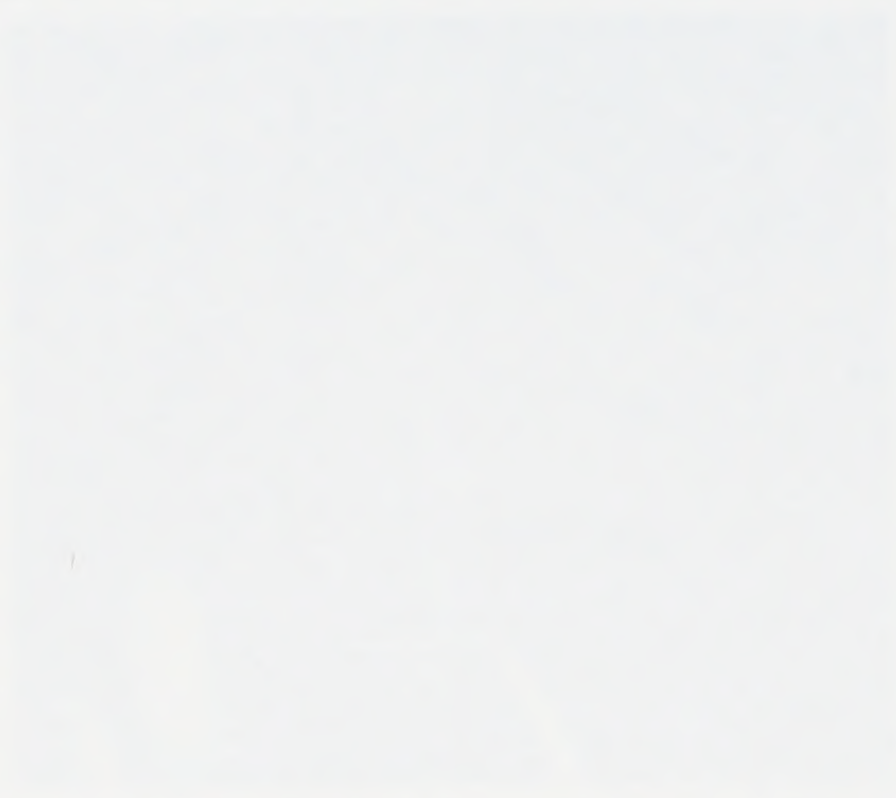
GASES FROM THE TEST WELL ON THE

UPPER OTTAWA ST. LANDFILL SITE

December 1982

MANN TESTING LABORATORIES LTD.

**PROFESSIONAL
ANALYTICAL SERVICES**



THE UNIVERSITY OF
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STUDY OF THE HISTORY OF THE UNITED STATES

1800-1860

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Summary

In order to evaluate the feasibility of burning the gases being emitted at the Ottawa Street Landfill Site, a pilot gas flaring project was undertaken by the Ottawa Street Landfill Site Study.

The gas well drilling, as well as the design and construction of the pumping/flaring apparatus was the responsibility of Conestoga-Rovers Associates. The chemical analysis of the pre and post flare gases was performed by Mann Testing Laboratories Ltd.

The main objectives of this experiment were to determine (a) whether the site produced enough methane to maintain a constant burning flare, (b) the degree of destruction of volatile organics contained in the gas, and (c) whether combustion of the gas produced any organics of a toxic or hazardous nature that would be released into the environment.

The first objective was met successfully. It was determined that there is sufficient (40%-60%) methane being produced on site to maintain a constant burning flame.

The second and third objectives were not met with the same success. This was due to an overly rich and hence inefficient flame, as well as location of the sampling probe. Corrective measures are suggested in the text of this report. Chemical analysis of the pre and post flare gases yielded high concentrations (>100 ppm) of acetone, butanone, toluene and xylenes. Chlorinated solvents and hydrocarbons were found in much lower concentration.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes the need for transparency and accountability in all financial dealings.

2. The second part of the document outlines the various methods and techniques used to collect and analyze data. It includes a detailed description of the experimental procedures and the statistical analysis performed.

3. The third part of the document presents the results of the study. It includes a series of tables and graphs that illustrate the findings of the research. The data shows a clear trend in the relationship between the variables studied.

4. The fourth part of the document discusses the implications of the findings. It suggests that the results of the study have significant implications for the field of research and may lead to further developments in the future.

5. The fifth part of the document concludes the study. It summarizes the main findings and reiterates the importance of the research. It also acknowledges the limitations of the study and suggests areas for further research.

Introduction

The analytical work presented here was performed during the period of October 20 to November 12, 1982. This work was requested by Anne Koven and is detailed in our proposal dated October 20, 1982.

The gas was sampled before and after the flare using air bags and tenax tubes. The schedule of sampling was altered slightly due to inclement weather conditions prevailing on October 20, the first day of sampling. The tenax tubes sampled on the first day, for 2 minutes and 5 minutes, were analyzed in the laboratory the same evening. The analysis indicated complete saturation of the 2 minute tubes, thus analysis on the 5 minute tubes was not performed. However, air bag samples taken October 20, were analyzed for volatile organics as well as methane. On October 21, 6 tenax tubes and 6 air bags were used to sample the gas before and after the flare. A summary of the samples taken are listed below.

<u>Tenax Tubes</u>	<u>Pre</u>	<u>Post</u>
October 20 - 1:30 pm	1 (2 min)	2 (2 min)
	3 (5 min)	4 (5 min)
October 21 - 1:00 pm	6 (15 sec)	7 (20 sec)
2:00 pm	8 (10 sec)	9 (20 sec)
3:00 pm	10 (10 sec)	11 (20 sec)

<u>Air Bags (5l)</u>	<u>Pre</u>	<u>Post</u>
October 20 - 1:30 pm	A	B
October 21 - 1:00 pm	C	D
2:00 pm	E	F
3:00 pm	G	H

The air bags were filled using an electric, oil-less pump. Although it was not necessary to use the pump on the pre-flare

sample (the gas was pressurized at the valve), it was needed on the post-flare sample. The pump was, therefore, used in the same manner to maintain sampling consistency. The pump was not completely sealed, thus fractionally diluting the air bag samples with ambient air. The degree of dilution was probably less than ten percent, although we have no basis for assuming this value, other than comparison of methane concentrations measured by us and Conestoga-Rovers Associates.

Analysis

(a) Air Bags

Five mls of gas were injected onto the concentrator unit and chromatographed on a 50 metre Superox 4-LL capillary column. The oven temperature was programmed from 30°C - 200°C at 8°C/minute. The eluants were analyzed by mass spectrometry on a Finnigan 3200 and the data acquired on an Incos data system. Quantitation of selected compounds was achieved by comparison to known amounts of the standards. Due to availability of standards, only ten compounds were quantitated. The other compounds are listed as approximate concentrations.

(b) Methane

The concentration of methane in the air bags was measured against a 100% methane standard. The air bags were filled with a pump that had a small leak in it, thereby diluting the sample slightly. The following concentrations were found.

		<u>Methane (%)</u>	
		<u>Pre</u>	<u>Post</u>
October 20	1:30 pm	42.9	28.3
October 21	1:00 pm	34.6	25.5
October 21	2:00 pm	41.4	44.1
October 21	<u>3:00 pm</u>	<u>44.8</u>	<u>37.1</u>
Average		40.9	33.9

(c) Tenax Tubes

Quantitation of constituents in the pre and post flaring of the well gas was determined by the air bag analysis, which we feel is a more accurate method of quantitation. However, the tenax tube provides greater sensitivity and allows us to detect lower concentration compounds which would otherwise not be detected by the air bag method. The tenax tubes were, in some instances, saturated with acetone, methyl ethyl ketone, toluene and xylenes. The tenax tube method detected all of those compounds detected by the air bag method. Compounds detected by the tenax tube method and not in the air bag method are listed in table II.

(d) Water Condensate

Approximately 300 mls of organic laden water was collected from a tap located at the bottom of the flare tubing. We decided to analyse this water via concentrator GC/MS to determine its volatile organic content. Two mls of this water were sparged for ten seconds only. (The water was saturated with organics). Analysis of the eluants indicated the presence of those components listed in Tables I and II.

Table 1

AIR BAG ANALYSISCONCENTRATIONS OF COMPONENTS IN FLARE GASES IN PPM (v/v)

	Oct 20/82		Oct 21/82		Oct 21/82		Oct 21/82	
	1:30 pm		1:00 pm		2:00 pm		3:00 pm	
	<u>Pre</u>	<u>Post</u>	<u>Pre</u>	<u>Post</u>	<u>Pre</u>	<u>Post</u>	<u>Pre</u>	<u>Post</u>
n-hexane	29	18	23	17	22	17	25	11
dichloroethylene	20	10	16	9	13	12	32	5
acetone	608	533	486	364	453	408	547	261
tetrahydrofuran	17	11	16	11	16	12	16	4
methyl ethyl ketone	154	88	99	61	90	81	92	44
benzene	7	6	8	5	7	7	6	2
toluene	256	133	242	157	244	221	245	64
ethyl benzene	81	40	71	46	79	65	71	28
trichloroethylene	1.4	0.8	1.4	0.5	1.1	0.8	1.2	0.2
1,4 dioxane	10	4	9	4	10	7	5	1
*butene (H/C)	10	5	8	5	6	6	8	5
*butanol	13	6	11	6	9	8	9	3
*hexane (H/C)	9	5	8	5	6	5	8	2
*hexanone (H/C)	90	39	86	41	84	81	58	7
*p-xylene	34	20	51	25	41	37	23	6
*o-xylene	192	105	220	125	205	170	184	61
*m-xylene	84	42	85	58	86	80	86	28
*C ₃ -benzene	10	2	15	7	19	9	11	2

*approximate concentrations

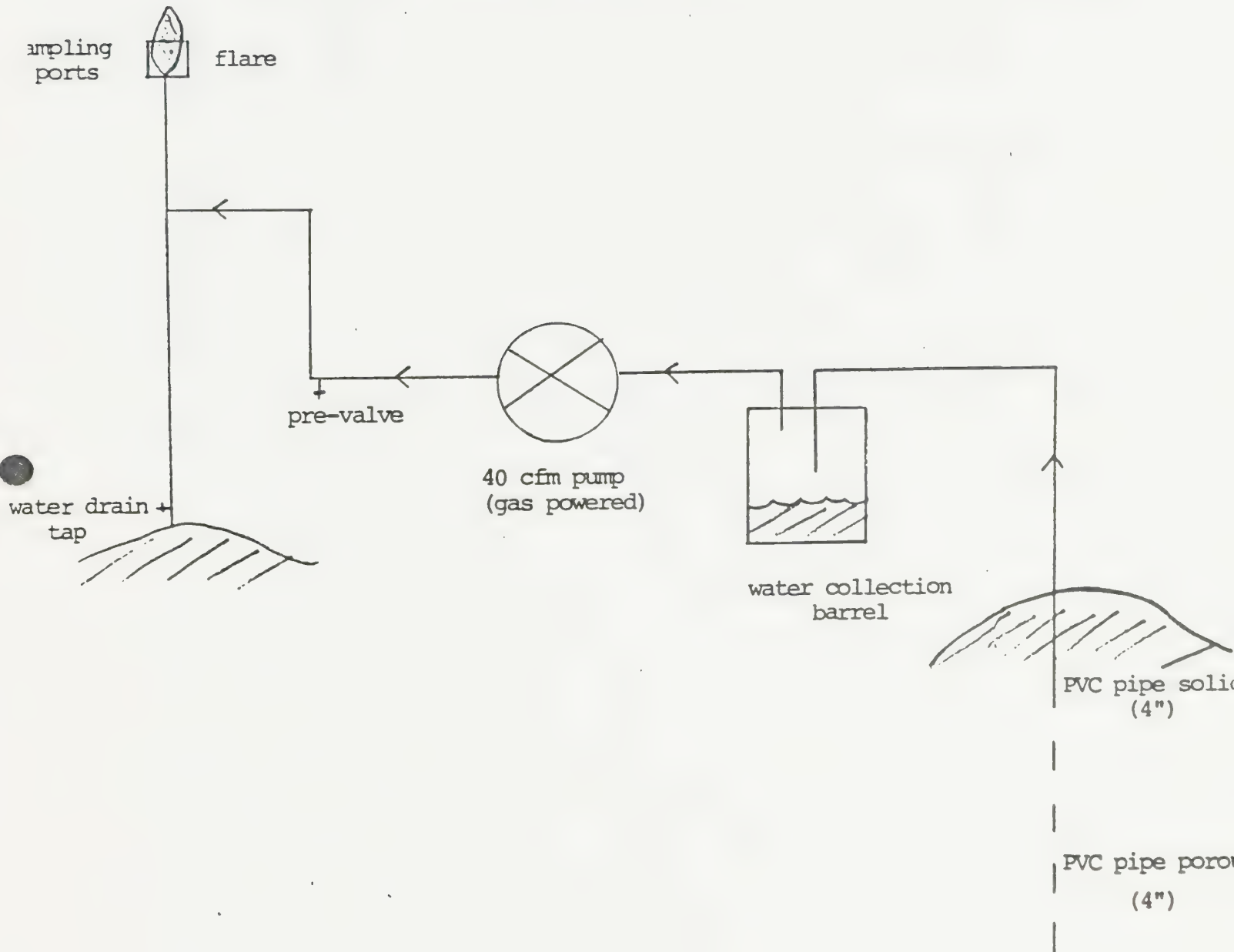
TABLE II

Compounds Detected by Tenax Tubes

- compounds in Table I
- isopropanol
- dichloroethane
- trichloroethane
- many alkyl hydrocarbons
- C₄-benzenes (many isomers)
- C₅-benzenes (many isomers)
- naphthalene (or azulene)
- indene
- methyl indene (many isomers)
- * - freon 113
- * - styrene
- * - methyl styrene
- * - benzaldehyde
- * - dichloromethane

*Source probably lab contamination.

PIPING SYSTEM OF GAS FLARE



Conclusion

The tenax tube sampling method proved to be too sensitive a method of sampling gases in the flare testing study. The power of the tenax tube method lies in detecting trace quantities of volatile organics. The air bag or gas cylinder sampling methods appear to be better suited to the high organic concentration gases collected from the gas well.

Analysis of the air bags, tenax tubes and water condensate indicates the presence of several volatile organic compounds in relatively high concentrations (i.e. >100 ppm). These are acetone, methyl ethyl ketone, toluene, and xylenes. The well gas also contains significant amounts of alkyl hydrocarbons, chlorinated solvents, low molecular weight alcohols, THF, dioxane, ketones, and C₃-C₅ benzenes.

The initial purpose of this flaring study was to determine the feasibility of burning the gas being emitted by the dump site. This objective was not accomplished due to unforeseen miscalculations in the design of the flaring experiment.

The analysis of the tenax tubes and air bags raised certain questions regarding what exactly we were sampling. A two-foot aluminum probe was inserted into the top part of the flare housing containing the flame. The flame however, wavered and extended beyond the top of the flare housing, indicating that we were actually sampling a mixture of heated gas, burning gas and burned gas, as well ambient air that provided the oxygen for the burning process. In order to burn methane efficiently, there must be at least twice as much oxygen present, according to the balanced equation:



The concentrations of methane and oxygen in the well gas are approximately 50% and 0%, respectively. The well gas must, therefore, be diluted with ambient air to obtain a methane:oxygen ratio of 1:2 (or 0.5). The maximum oxygen concentration attainable is 21% (no well gas) and this would indicate that the well gas should be mixed with air to obtain a final concentration of 8% methane. (See table III).

Table III

<u>Well gas (l)</u>	<u>Methane(l)</u>	<u>Air(l)</u>	<u>Oxygen (l)</u>	<u>Methane/Oxygen</u>	<u>Ideal ratio</u>
1	0.5	1	0.2	2.5	0.5
1	0.5	2	0.4	1.25	0.5
1	0.5	3	0.6	0.83	0.5
1	0.5	4	0.8	0.63	0.5
1	0.5	5	1.0	0.50	0.5
1	0.5	6	1.2	0.42	0.5
1	0.5	7	1.4	0.36	0.5
1	0.5	8	1.6	0.33	0.5
1	0.5	9	1.8	0.27	0.5
1	0.5	10	2.0	0.25	0.5

In order to insure that enough oxygen is present to completely combust the methane plus organics, a safety factor of extra oxygen should be included which would increase the dilution factor from 5 to 8. Since the concentration of nitrogen (inert) can be measured in the pre and post flare gases, the exact dilution factor can be calculated. The temperature of an efficiently burning methane flame is documented at between 1700 to 2000°C, which is high enough to completely combust almost every compound detected in the gas well. As long as the oxygen is in excess, and the flame temperature exceeds 1500°C, one may assume complete destruction of organics, including chlorinated organics.

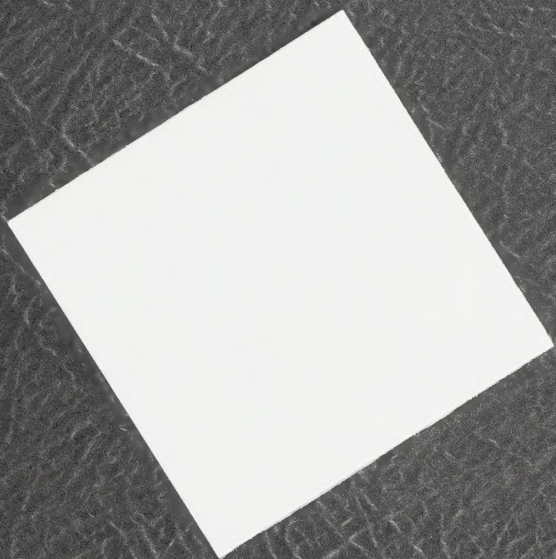
Recommendations

The post flare gas sample should contain no methane under optimum conditions. In this case, the tenax tube analysis method could be used to concentrate and detect trace combustion products other than H_2O and CO_2 .

In order to evaluate the efficiency of burning as well as the true combustion products, a chimney should be installed that would contain the entire flame.

It has been determined that there is enough methane under the site to maintain a constant burning flare. The first priority of the flaring design should be to ensure that the burning is complete. That is, to ensure that there is an excess of oxygen in the flame, and no methane after the flame. Once these conditions have been determined, analysis of the post flare gases should be undertaken to determine:

- (a) if there are any compounds present in the pre-flare gas that are not being burned,
- (b) if there are any compounds being formed in the flame, and whether or not, they are of a toxic or hazardous nature.
- (c) the concentration of compounds from (a) and/or (b)



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